Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Joint Canada-USA Field Survey of the Charr (*Salvelinus sp.*) Resources of the Firth River, Yukon Territory and Alaska, September, 1989

A. Kristofferson, D. Wiswar, P. Lemieux, D. Marshall,
A. Blouw, C. Hemming, G. Antoniuk and W. Archie

Central and Arctic Region
Department of Fisheries and Oceans
Winnipeg, Manitoba
R3T 2N6

1991

Canadian Data Report of
Fisheries and Aquatic Sciences
No. 861

Fisheries Pêches

Canadian Data Report of Fisheries and Aquatic Sciences

Data reports provide a medium for filing and archiving data compilations where little or no analysis is included. Such compilations commonly will have been prepared in support of other journal publications or reports. The subject matter of data reports reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Data reports are not intended for general distribution and the contents must not be referred to in other publications without prior written authorization from the issuing establishment. The correct citation appears above the abstract of each report. Data reports are abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–25 in this series were issued as Fisheries and Marine Service Data Records. Numbers 26–160 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Data Reports. The current series name was introduced with the publication of report number 161.

Data reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport statistique canadien des sciences halieutiques et aquatiques

Les rapports statistiques servent à classer et à archiver les compilations de données pour lesquelles il y a peu ou point d'analyse. Ces compilations auront d'ordinaire été préparées à l'appui d'autres publications ou rapports. Les sujets des rapports statistiques reflètent la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports statistiques ne sont pas destinés à une vaste distribution et leur contenu ne doit pas être mentionné dans une publication sans autorisation écrite préalable de l'établissement auteur. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports statistiques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 25 de cette série ont été publiés à titre de relevés statistiques, Services des pêches et de la mer. Les numéros 26 à 160 ont été publiés à titre de rapports statistiques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 161.

Les rapports statistiques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Data Report of

Fisheries and Aquatic Sciences 861

1991

JOINT CANADA-USA FIELD SURVEY OF THE CHARR (*Salvelinus sp.*) RESOURCES OF THE FIRTH RIVER, YUKON TERRITORY AND ALASKA, SEPTEMBER, 1989

by

A. Kristofferson, D. Wiswar, P. Lemieux, D. Marshall,

A. Blouw, C. Hemming, G. Antoniuk and W. Archie

Central and Arctic Region

Department of Fisheries and Oceans

Winnipeg, Manitoba R3T 2N6

This is the 68th Data Report

from the Central and Arctic Region, Winnipeg

©Minister of Supply and Services Canada 1991

Cat. no. Fs 97-13/861E ISSN 0706-6465

Correct citation for this publication is:

Kristofferson, A., D. Wiswar, P. Lemieux, D. Marshall, A. Blouw, C. Hemming, G. Antoniuk, and W. Archie. 1991. Joint Canada-USA field survey of the charr (Salvelinus sp.) resources of the Firth River, Yukon Territory and Alaska, September, 1989. Can. Data Rep. Fish. Aquat. Sci. 861: iv + 21 p.

TABLE OF CONTENTS

	Page
ABSTRACT/RÉSUMÉ	iv
INTRODUCTION	1
MATERIALS AND METHODS	1
Aerial reconnaissance	1
Photography	2
Seining	2
RESULTS	2
Aerial reconnaissance	2
Photography	4
Seining	5
FUTURE INITIATIVES	7
ACKNOWLEDGMENTS	8
REFERENCES	8

LIST OF FIGURES

Figure		Page
1	Map showing the Firth River study area within the Arctic National Wildlife Refuge, Northern Yukon National Park and Inuvialuit Settlement Region	10
2	The Canadian Parks Service facility at Sheep Creek	11
3	Map of the Firth River and Joe Creek showing the CPS facility at Sheep Creek and the extent of the aerial reconnaissance flights	12
4	Map of the confluence of Joe Creek and the Firth River showing sites surveyed for placement of a deflection-board weir operation	13
5	Map of the upper Firth River and Joe Creek showing seining sites, under water photography sites and concentrations of fishes and/or redds	14
6	Aerial photograph of spawning grounds in the upper Firth River	15
7	Aerial photograph of a seine net haul in the upper Firth River	16
8	Underwater photograph of charr and Arctic grayling on spawning grounds in the upper Firth River	17
9	Photograph of Firth River charr showing male and female current-year spawners and a returning "silver" searun migrant	18
10	International field crew sampling charr on the Yukon/ Alaska border after a successful seine haul	19

LIST OF TABLES

Table		Page
1	Estimated number of fishes and redds in the upper Firth River, 16 September 1989, based on aerial photography (videotape)	20
2	Record of seine net catches in the upper Firth River, September 1989	20
3	Biological data from charr captured by seine net in the upper Firth River, September 1989	21

ABSTRACT

Kristofferson, A., D. Wiswar, P. Lemieux, D. Marshall, A. Blouw, C. Hemming, G. Antoniuk, and W. Archie. 1991. Joint Canada-USA field survey of the charr (Salvelinus sp.) resources of the Firth River, Yukon Territory and Alaska, September, 1989. Can. Data Rep. Fish. Aquat. Sci. 861: iv + 21 p.

A joint Canada-USA field survey was carried out on the Firth River, Yukon Territory and Alaska during 13-19 September 1989. The objectives were to familiarize Canadian and US personnel with the field conditions at the Firth River and to evaluate aerial and underwater photography and seining as methods of enumeration of charr in this system. The results will be used to develop a detailed research program to assess the charr resources in the Firth River. All three methods showed promise under particular circumstances. Three locations along the river course were examined at ground level and were determined to be suitable for installation of a deflection-board fish weir for direct enumeration of charr. A record of the field survey was made on videotape. The results of the survey are presented in this report.

Key words: aerial photography; fishery surveys; seining; underwater photography; population number.

RÉSUMÉ

Kristofferson, A., D. Wiswar, P. Lemieux, D. Marshall, A. Blouw, C. Hemming, G. Antoniuk, and W. Archie. 1991. Joint Canada-USA field survey of the charr (Salvelinus sp.) resources of the Firth River, Yukon Territory and Alaska, September, 1989. Can. Data Rep. Fish. Aquat. Sci. 861: iv + 21 p.

Du 13 au 19 septembre 1989, le Canada et les États-Unis ont réalisé conjointement un relevé sur le terrain de la rivière Firth dont une partie se trouve dans le Territoire du Yukon et l'autre en Alaska. Les objectifs de l'enquête étaient de permettre aux équipes canadiennes et américaines de se familiariser avec les conditions prévalant dans la région de la rivière Firth et d'évaluer l'utilité de la photographie aérienne, de la photographie sous-marine et du sennage pour dénombrer les ombles dans cette rivière. Les résultats serviront à élaborer un programme de recherche détaillé pour l'évaluation des ressources en ombles de la rivière Firth. Utilisées dans des conditions particulières, les trois méthodes semblent prometteuses. On a examiné sur le terrain trois endroits situés le long de la rivière qui se prêtent à l'installation de panneaux de déviation des poissons permettant le dénombrement direct des ombles. On a enregistré l'enquête sur vidéocassette. Le présent rapport porte sur les résultats de l'enquête.

Mots-clés: photographie aérienne; enquêtes sur la pêche; sennage; photographie sous-marine; effectif d'une population.

INTRODUCTION

A transboundary stock of anadromous fish of the genus Salvelinus is known to utilize the Firth River system, with spawning, rearing and overwintering sites on both sides of the Alaska/Yukon border. At present there is taxonomic uncertainty at the species level as to whether these charr should be considered as representative of Salvelinus alpinus, the Arctic charr, or as S. malma, the Dolly Varden charr. McPhail (1961) used meristic characters and geographic location to describe a northern and southern form of S. malma and a western and eastern form of S. alpinus. McCart (1980) suggests that McPhail's distinctions may have been too complex and that his (McPhail's) northern Dolly Varden and western Arctic-Bering Sea Arctic charr are the same species. Glova and McCart (1974) considered the anadromous charr of the Firth River to be Salvelinus alpinus. McCart (1980) considered these charr to be the western form of S. alpinus, in contradistinction to the eastern form of S. alpinus. Morrow (1980) concluded, on morphological and ecological grounds, that the so-called western form was S. malma. More recently, Reist et al. (1990) have provided additional evidence (morphology and enzyme analyses) that suggests that the Firth River charr are S. malma. Considering the above, only the generic term "charr" is used throughout this report.

Regardless of the ultimate outcome of the taxonomic debate, the charr of the Firth River represent a valuable resource to the peoples of the region. Tagging studies indicate that Firth River charr are harvested by U.S. and Canadian fishermen in nearshore coastal waters. Although exploitation is light at present, it is anticipated that it will increase in future. Increased recreational, subsistence and commercial fishing have potential to impact this stock. To ensure that this stock is wisely used by both nations, a Safe Harvest Level (SHL) must be determined. Although the population dynamics of charr in the Firth River are not well understood at present, studies of charr (S. alpinus) in the central Canadian arctic suggest that annual exploitation in excess of 10% of the upstream run was detrimental to the stock and led to a decline in numbers in some cases (Johnson 1980). Thus, a SHL for charr in the Firth River should not exceed 10% at this time.

The Firth River lies within the Arctic National Wildlife Refuge on the U.S. side of the border and the Northern Yukon National Park on the Canadian side. The latter is encompassed by the Inuvialuit Settlement Region (Fig. 1). Canada's Department of Fisheries and Oceans (DFO) is responsible for the management of charr along the Yukon coast. The Fisheries Joint Management Committee (FJMC), a joint Canada/ Inuvialuit committee, is responsible for finalizing management plans within the Inuvialuit Settlement Region. The Canadian Parks Service (CPS) regulates fisheries activities within the boundaries of the Northern Yukon National Park. The Alaska Department of Fish and Game (ADF&G) has management responsibility for all sport, commercial and subsistence fisheries on the Alaskan side of the border. In addition, land use activities in anadromous streams are regulated by the ADF&G under the Anadromous Fish Act. The United States Fish and Wildlife Service (USFWS) has land and habitat management responsibility within the Arctic National Wildlife Refuge. Thus, a meaningful study of the Firth River charr must necessarily involve all of the above-mentioned agencies.

The need for a joint Canada/U.S. study was recognized at a meeting in Banff, Alberta in December, 1986. This need was further emphasized at a meeting at Chena Hot Springs, Alaska in January, 1989. It was decided at the latter meeting that a preliminary field survey of the Firth River would be carried out in September, 1989, with participation by representatives of all of the above-mentioned agencies. This preliminary survey was intended to ensure that personnel from all the agencies gain on-site experience at the Firth River such that a comprehensive assessment of the charr stock could be planned for future implementation. The survey also provided an opportunity to evaluate a number of stock assessment techniques for the future study. The techniques included aerial and underwater photography and seining. A reconnaissance of the river course was accomplished to select a suitable site for a deflection-board weir. This report provides a summary of the field survey.

MATERIALS AND METHODS

The following personnel participated in the survey:

Dick Marshall	USFWS Anchorage AK, USA
David Wiswar	USFWS Fairbanks AK, USA
Carl Hemming	ADF&G Fairbanks AK, USA
Bill Archie	INUVIALUIT Aklavik NT, CANADA
Gord Antoniuk	CPS Inuvik NT, CANADA
Pierre Lemieux	DFO Inuvik NT, CANADA
Andries Blouw	DFO Winnipeg MB, CANADA
Al Kristofferson	DFO Winnipeg MB, CANADA

The base camp for the field survey was the CPS facility at Sheep Creek (Fig. 2, 3). The Canadian crew arrived at the camp on 10 September 1989. The US crew were delayed by bad weather along the coast and arrived by helicopter from Kaktovik, Alaska on 13 September.

The Sheep Creek facility consisted of two large Weather Haven fabric-covered structures, one of which contained the kitchen/dining area and office and the other functioned as a dormitory with eight bedrooms and two washrooms. Power was supplied by a diesel-electric generator. A workshop and storage facility were located in detached, rigid out-buildings. A helicopter pad was located adjacent to the main office. The camp was located on the northeast bank of the creek about 0.5 km upstream of the confluence with the mainstem Firth River. A 240 m airstrip was located on a flat plain directly above the camp. The strip was oriented perpendicular to the creek and ended

abruptly at the edge of the bank. CPS policy limited the use of the airstrip by fixed-wing aircraft to freight hauls only. Passengers accessed the camp by helicopter.

AERIAL RECONNAISSANCE

Overflights were made in a Bell 206B Jet Ranger helicopter at altitudes of 50 m to 150 m and speeds that were slow enough to enable onboard observers to determine potential sites along the river course for the installation of a deflection-board weir. A ground crew later investigated potential weir sites by wading into the river and measuring the breadth and depth of the channel. Surface water velocity was estimated by timing a floating object over a measured distance.

The mainstem Firth River was observed from the delta to the Alaska-Yukon border and upstream approximately 28 km into the Arctic National Wildlife Refuge. Additionally, Joe Creek was overflown from its confluence with the Firth River to a point approximately 20 km upstream of the border. A record of the river course was made with a Sony EVO-120 8 mm Handycam video camera equipped with a 12-72 mm lens. A detailed description of the Firth River is given by Glova and McCart (1974).

PHOTOGRAPHY

Aerial

An attempt was made to obtain a photographic/video record of concentrations of fishes in the upstream areas. Charr are sympatric with Arctic grayling (Thymallus arcticus) in the Firth River (Glova and McCart 1974) and cannot be distinguished by species from the air. The starboard rear door of the helicopter was removed to allow an unimpeded view and the cameraman was strapped in by means of a harness. The helicopter was flown along the river until fishes and/or spawning redds were observed in the water below. These were then recorded on videotape from an altitude of approximately 100 m and the location was marked on a map. The tapes were then viewed in the laboratory to determine the suitability of this technique for censusing fish. Still photographs of some of the concentrations of fishes were also made using a Hasselblad 500 CM camera with 50 mm, 80 mm, and 150 mm Zeiss lenses and Ektachrome 100 Plus film. Color slides were also taken with a Canon AE-1 SLR camera and a 50 mm lens using Kodachrome 64 ASA film at 1/250th second with automatic exposure.

Underwater

The cameraman, wearing a drysuit, was pulled upstream along the surface of a large pool by means of a long line to a crew on shore. Fishes holding in the pool were recorded with the video camera using an Amphibico V9 underwater housing and a water-corrected fisheye lens. Still photographs were taken with a Nikonos 35 mm underwater camera with a 20 mm lens. Kodachrome 64 ASA color slide film was used. The cameraman was then detached from the line and allowed to drift downstream to the base of the pool, photographing fishes along the way.

SEINING

Pools which were determined from the air to contain concentrations of fishes were seined using a modified monofilament herring gillnet (approximately 50 m long, 2 m deep, 57 mm stretched mesh) or a black-coloured multi-strand beach seine (46 m long, 2.1 m deep, 51 mm stretched mesh). A crew of 4-6 people would set the net by paying it out downstream along the far bank. The downstream end of the net was connected to the near shore by a 13 mm-thick floating polypropylene line. The crew would then cross to the near shore and pull the net diagonally downstream with the aid of the current. The procedure was directed by an observer hovering above in the helicopter. In most cases, a record of the set was made on videotape to observe the response of the fish to entrapment in the net. Charr captured in the initial seine haul at a given location were measured (fork length) and marked by removal of the adipose fin and then released at the capture site. Additional charr were captured by angling and marked and released in the same manner. A Petersen estimate (Ricker 1975) of the number of charr holding in the pool was to be attempted using the ratio of marked-to-unmarked individuals in the succeeding seine hauls.

RESULTS

All videotape records are available at the Freshwater Institute, 501 University Cres., Winnipeg, MB, Canada, for review.

AERIAL RECONNAISSANCE

A videotape record of the aerial reconnaissance was made. The numbered sections shown in Fig. 3 were identified on the audio portion of the tape as each particular section was overflown. Following is a description of major segments of the river course:

Firth River delta to confluence with Joe Creek

The delta was observed from an altitude of 50-150 m. The delta was comprised of a myriad of shallow and shifting channels making this area totally unsuitable for the operation of a deflection-board weir. Upstream of the delta the water in the river was high, fast, and turbid following three days of rain. For the most part the river was fast-flowing and the banks rocky and steep-cut. No suitable weir sites were found from the mouth of the Firth River to its confluence with Joe Creek (Fig. 3).

Firth River-confluence with Joe Creek to Margaret Lake

Above the confluence, water in the mainstem Firth River was clear in spite of the previous days' rainfall. Suspended material entered the river from Joe Creek. The flow in the Firth River just above Joe Creek was noticeably slower than that observed downstream. At this location the river was also wider and appeared to be shallow. The location was noted as a possible weir site to be examined more closely by a ground crew at a later date. Fishes were first observed in the river just below its confluence with Muskeg Creek (Fig. 3) and redds were visible as well.

Firth River-Margaret Lake to Alaska border

Concentrations of fishes were observed in the river above the lake. The river was extensively braided about 5-6 km upstream of the lake. This braided area extended upstream for about 19 km and was part of a broad gravel floodplain which continued into Alaska. Considerable upwelling of springwater had produced large aufeis fields in winter which still existed at the time of the study. This area is referred to by Glova and McCart (1974) as Aufeis-A.

Travelling upstream, the middle and right side of the braided area were comprised of numerous shallow channels. No fishes were observed here. The right bank was a gently rising slope while the left bank bordered a steep rock face. The main channel of the river ran along this rock face. Numerous concentrations of fishes were observed holding in pools along this section. Approximately 4-5 km from the head of the braided area, the main channel angled away from the rock face. Concentrations of fishes and many redds were observed in this portion of the stream, just below a small butte-like feature rising from the flood plain. Another concentration of fishes and more redds were observed in the main channel at a point opposite the confluence with You Creek (Fig. 3). Immediately above this point the mainstem Firth River narrowed to a single channel, opposite the confluence with Mancha Creek. The latter drained into the Firth River through a series of small channels. Fishes and redds were observed along this single stretch. The stream was braided again from a point 3 km below the Yukon/Alaska border. Topography was essentially a flat featureless gravel plain. Aufeis fields were present here. Glova and McCart (1974) identify the one just upstream of a steep rock face as Aufeis-B and another on the Yukon/-Alaska border as Aufeis-C. Throughout this braided stretch, fishes and redds were observed in the main channels.

Firth River-Alaska border to headwaters

Upstream of the border, braiding was not as extensive and the main channel was more apparent. Willows and conifers were encountered in clumps along the banks and deadfalls were evident in some places in the stream channel. Although concentrations of fishes and redds were not as large as those observed downstream, they were quite prevalent along the stretch up to the forks of the mainstem, 14 km upstream of the border. At the forks, the right channel was followed for a distance of 14 km until the stream flow diminished to the point where fish passage did not appear to be possible (Fig. 3). Fishes and redds were observed as far as 4 km upstream of the forks. No fishes were sighted beyond this point in this channel. No fishes or redds were observed in the 6 km of the left fork that was surveyed.

Joe Creek

The stream was braided just above its confluence with the Firth River to within 4-5 km of the Alaska border. The water was turbid upstream to the outlet of Aspen Creek (Fig. 3), the suspended material apparently originating in the latter tributary. The multiple channels preclude the use of a weir. Fishes were sighted in a small pool at the head of the braided area at the base of a rock promontory. Redds were observed at the base of a cliff. At this point the water was very clear but the stream was boulder-strewn. The stream was confined to one or two main channels for a distance of about 4 km on either side of the border. The stream was braided in a broad valley on the Alaskan side of the border. The main channel was followed to a point 20 km above the border (Fig. 3). No fishes were sighted and no suitable weir sites were found.

A tributary flowing into Joe Creek from the north 12 km upstream of the border was overflown. Some fishes were sighted in a small pool against a rock face. Surface stream flow in this tributary ceased about 4 km from the main channel area.

Weir sites

A possible weir site on Joe Creek was located from the air just upstream from its confluence with the Firth River (Fig. 4). A ground crew determined that the channel was 34 m wide at the selected location with a nearly uniform depth of 0.65 m. Surface water velocity was estimated to be 1 $m \cdot sec^{-1}$. The gravel banks rose gently on either side of the channel for a distance of 35-45 m. The site was judged to be suitable for the operation of a deflection-board weir; however, the fast current could make installation difficult.

A suitable weir site was found on the Firth River approximately 4.5 km upstream from the confluence with Joe Creek (Fig. 4). The channel was 59 m wide with a depth ranging from 0.4-0.8 m and an even bottom contour. The gravel banks on either side rose gently for a distance of 13-17 m. Facing upstream, the left side of the channel was the deepest. Surface water velocity was estimated to be 0.9 $m \cdot sec^{-1}$. An alternate site on the Firth River immediately upstream of the confluence with Joe Creek could possibly be used. However, bottom contour was very uneven, the channel was narrow at this location, and the water velocity was higher than at the other location examined.

Considering the distance between the two sites, two separate field camps would be necessary if both Joe Creek and the Firth River were examined in the same year. The lack of a suitable landing site for fixed-wing aircraft at each location makes the transportation of weir material difficult and expensive. Float-equipped aircraft as large as the De Havilland Twin Otter can operate out of Margaret Lake, but the value of this location as a staging base is questionable because the Sheep Creek airstrip is closer to the weir sites identified in this report.

At least a dozen grizzly bears, both lone animals and females with cubs, were sighted along the Firth River from the delta to the headwaters during the course of this survey. Although there were no bear-human confrontations during this survey, planners are advised to consider implementing some form of bear deterrent to prevent such encounters if, in future, a weir is to be operated in this area for an extended period of time.

PHOTOGRAPHY

Aerial

The helicopter provided an ideal platform for the aerial photography. It's maneuverability, slow speed, and ability to hover were essential to photographing the winding river course. The videotape record of the Firth River and Joe Creek watercourses has proven particularly valuable for reference. At the altitude and speed flown, sufficient detail was present to provide viewers with a clear understanding of where a weir may or may not work.

A survey of the upper Firth River from Joe Creek to the headwaters was completed on 16 September to assess the technique of aerial photography for counting charr. By this time, the results from seine hauls indicated that the concentrations of fishes observed during the aerial reconnaissance were, for the most part, charr. Results are shown in Table 1 and Fig. 5. A videotape record of the areas where fishes and/or redds were observed was made. The coded sections shown in Fig. 5 were identified on the audio portion of the tape as each particular section was overflown.

The waters of the Firth River above Joe Creek were exceptionally clear (even after a three-day period of precipitation) and shallow (1-2 m), providing good conditions for aerial observation of charr. Both the video and the still photography showed some promise with respect to counting fish under these circumstances. The still photography was particularly useful in providing a record of the spawning grounds. The redds were very obvious and appeared as light-colored oblong patches against the darker stream bottom (Fig. 6). Redds were about 1-1.5 m in length and 0.5-1 m in width. The redds could be easily counted from a color slide. A complete record of redds was not made using still photography. However, the spawning beds were recorded on videotape. Analysis of the videotape indicated that 1 500-2 300 redds were visible in the upper Firth River. Approximately 30-40% were on the Alaskan side of the border.

Where still photographs of fishes were taken, they proved most useful for counting purposes if the fish were evenly distributed over a light-colored substrate. This was most frequently encountered on the spawning beds which were occupied by the larger (450-650 mm) charr and Arctic grayling (Fig. 6). On the other hand large schools of smaller fishes (250-350 mm) appeared as dark blobs in the water and were difficult to enumerate due to the three-dimensional aspect of the school. The videotape appeared to be more useful in the enumeration. Fishes were often observed holding against the banks over a dark substrate and were not readily visible on still photographs (Fig. 7). However, the presence of the helicopter overhead worked to advantage, causing the fishes to scatter, often over the lighter-colored substrate in the middle of the channel. The movement of fishes was easily detected on the videotape and estimates of numbers could then be made by freeze-framing the tape and counting as one would from a still photograph. Analysis of the videotape of the upper reaches of the Firth River indicated the presence of a minimum of approximately 8 000-11 000 fish (Table 1, Fig. 5). This minimum estimate is discussed below.

Although videotapeing offers promise, this counting method is not without problems. When photographing from the helicopter, shooting through the windows produced distortion and reflection caused by the optical properties of the curved plexi-glass. This was overcome by removing the door. The cameraman was then exposed to the elements. Prolonged exposure at this time of year can produce discomfort which can affect the quality of the footage. The latter problem was eliminated toward the end of the survey by installing a special door on the helicopter, equipped with a sliding camera port. Essential to the quality of both still and video photography is a stable aerial platform. The helicopter, by its very nature, produced considerable vibration. This can be damped to a large extent by the cameraman himself but cannot be entirely eliminated. Hand-held gyro-stabilizing camera equipment is available to deal with this. Use of a helicopter with more than two rotor blades would reduce vibration as well.

Glare on the surface of the water reduces visibility to zero. Polarizing lenses were not used to eliminate glare because they tend to darken the picture. Rather, the helicopter was maneuvered to a position where glare could, in most cases, be eliminated. The presence of snow on the river banks also caused problems. The automatic exposure on the video camera worked well when the lens covered only the dark surface of the water. However, when a portion of the white, snow-covered bank came into view, the camera would expose for the snow and underexpose the water, blotting out the view of fish in the stream. A video camera equipped with spot metering would overcome this problem.

Perhaps the most significant difficulty encountered was the reduction in visibility into the water caused by surface disturbance. The downwash from the helicopter rotor blades produced this effect but could be eliminated by flying at a higher altitude. The zoom feature on the lens allowed for good resolution at the higher altitude but, in return, made the picture more sensitive to vibration. Overall this difficulty could be overcome by modifications to the technique. However, the videotape technique performed poorly in areas where fishes were moving through riffles. The fishes were visible to the naked eye and on video tape as a result of their movement, but not to the extent where a reliable estimate of numbers could be made. Many fishes were photographed in riffle areas in the large braided sections of the river (Fig. 5, Table 1) but an accurate estimate of their numbers was not possible. The numerical estimate referred to earlier in this section was based, for the most part, on footage of fishes in sections of the river where they were readily visible. Thus, it constitutes a minimum estimate.

An additional problem associated with the aerial census was the presence of Arctic grayling, mentioned earlier in this report. Seining on the spawning grounds produced a mixture of charr and Arctic grayling. In two seine hauls Arctic grayling comprised 32% and 47% (Table 2) of the catch, respectively. It was impossible to distinguish between the two species in the aerial photographs. Arctic grayling did not appear in any number when a large school of small non-spawning charr was seined, but their presence in the river must be taken into consideration if aerial photography is to be used as a census technique.

The use of a helicopter is essential to conduct the aerial photography discussed here. Therefore, the cost of operating such equipment, which can range from $500-$800 per hour, is a significant factor which must be considered when developing a research plan for future studies.

Difficulties notwithstanding, the use of aerial photography for censusing charr in the Firth River should be considered. The helicopter must be flown in a level attitude at a time of day (midday is the best) and at an angle that eliminates glare and at an altitude (at least 100 m) where the downwash does not disturb the surface of the water. By shooting through a camera window and slowly panning the camera along the stream, videotapes of a quality sufficient for counting charr in quiet water can be made. The videotape provides an excellent record of the distribution and abundance of redds on the spawning grounds.

Underwater

Underwater photography was attempted on the afternoon of 17 September under sunny conditions. Water temperature ranged from 2-4°C. Two pools immediately below the border (Fig. 5) were selected because they contained fishes and redds were evident over a large portion of the bottom. That section of the river was of sufficient depth (at least 1 m) to allow the photographer to maneuver freely. The exceptional clarity of the water provided ideal conditions and resulted in very good photographs, both video and still. The pool contained a mixture of charr and Arctic grayling. The photographer estimated that Arctic grayling comprised 30% of the fish. The rope tether on the photographer was very effective when moving him upstream against the current. Through hand signals he was able to notify the crew on shore when he wanted to advance or stop. Although the fishes kept their distance they did not appear to be frightened. Drifting downstream with the current was effective as well. Under water, charr could readily be distinguished from Arctic grayling (Fig. 8). Amongst the charr, the spawning males were most conspicuous by their red color and the immaculate white leading edge of the paired and anal fins (Fig. 9). Spawning females were evident by their thin bodies (Fig. 9). That is, they were in spawning livery but appeared to be spent. Returning searun charr, robust in condition (Fig. 9) with silvery sides were also present in the pool.

Underwater observation can be effective in determining the species composition of pools in this area. This technique has value for educational purposes or for evaluation of site-specific habitat features. A photographic record is useful in determining the relative numbers of each species present. This information would be very valuable when used in conjunction with aerial photography if the latter were used for counting fish. However, it would be rather time-consuming over a large area. A record of the underwater video footage is available for reference.

SEINING

A total of nine seine hauls were made on the upper Firth River during the survey. Five different sites were investigated (Fig. 5). Results are shown in Table 2.

The first and second seine hauls took place in a pool near the confluence of Muskeg Creek. The modified herring net was used. Less than half the area of the pool could be effectively seined due to its size and the depth of the water. The first haul captured 53 charr. Fifteen charr were marked and released at the capture site prior to the second haul. The second haul produced 26 charr but no marked charr were recaptured. Water temperature at this site was 2.2°C.

The third seine haul was near the head of the large braided area called Aufeis-A (Fig. 5). Again, the modified herring net was used. A large concentration of fishes was observed from the air to be holding in a pool that was small enough to encircle with the net. As observed from the helicopter hovering above the pool, the entire concentration of fishes was initially trapped within the net. However, as the net was drawn in close to shore at the downstream end of the pool, fishes were seen to charge upstream en masse, disturbing the surface of the water in the process.

The fish were seen to strike the net and most, perhaps as much as 75%, escaped upstream. When the net was pulled ashore it contained 269 charr, the majority of which were caught by the gills in the monofilament mesh. These charr were almost exclusively bright silver on the flanks, in the 250-350 mm size range. All were released at the capture site as soon as possible with no apparent mortality. Water temperature in the stream reach was 4°C.

The net was examined on shore after the fish were released. A tear in the net, approximately 2 m in length, was found running parallel to and about 0.2 m above the lead line. It is not known whether this damage was caused by the charr striking the net or by abrasion with the stream bottom. Most certainly some of the charr escaped through this hole. More likely, contact with the net by the large numbers of charr resulted in the lead line rising above the bottom thus allowing the charr to escape under the net. If indeed about 75% of the charr which were initially entrapped did escape, the original concentration could have comprised as many as 1000 charr. In future, if this type of gear is used, attempts should not be made to entrap such large numbers of fish as the chances of successfully landing them are likely to be small.

Seine hauls four and five were made using the modified herring net near the head of Aufeis-A, and opposite the confluence of You Creek (Fig. 5). Two adjacent pools were used. Fifty-four charr, one of which was marked with a Floy anchor tag (FC 61880), were captured in the upstream pool. The charr had been tagged by DFO and CPS employees in the upstream Firth River on 31 August 1987. It was 545 mm in length when tagged and 680 mm at recovery and did not appear to be in spawning condition at either time. A second charr marked with a Floy anchor tag (FC 61940) was angled at this location. It had been captured in the Firth River on 30 August 1987. It measured 485 mm at tagging and 598 mm at recovery and did not appear to be in spawning condition at either time. The remaining charr were marked and 19 were measured. All were subsequently released at the capture site.

The fifth haul, from the downstream pool, captured 123 charr. Two of the charr had been marked by removal of the adipose fin, presumably after the fourth haul. Most of the charr in the fifth haul were smaller than in the fourth. They were mostly uniform in size with some measured in the 250-350 mm range. Similar to the third haul, most were caught by the gills. Every effort was made to remove them quickly from the net and release them. No mortality was apparent. Water temperature at this location was 4.5°C. A Petersen estimate of numbers based on these recaptured fish cannot be made because the marked fish were released into the upstream pool, whereas the recoveries were made in the downstream pool. In all probability, the marked charr were not evenly distributed within both pools after their release into the upstream pool. However, the data suggest that at least two of the marked charr moved downstream after they were released.

Seine hauls six, seven and eight were at a pool approximately 1 km below the border in the area know as Aufeis-B. From the air, redds were visible toward the upstream end of the pool and the fish appeared to be large and rather evenly distributed over the bottom, unlike the dense schools encountered downstream the previous two days. The black-colored, multi-strand beach seine was used in order to reduce the possibility of capturing the charr by the gills. As described in MATERIALS AND METHODS, the mesh size was 51 mm compared with 57 mm for the modified herring net. The net was set across the river at the head of the pool and allowed to drift downstream. A deep scour hole was present immediately below the riffle at the head of the pool. From the helicopter hovering above, fishes were seen to escape upstream by swimming under the net because it was not deep enough to reach the bottom at this point. However, as the net proceeded downstream into the shallow stretch, fishes were still seen to escape under the net. It was felt that this was due to the very light lead line on the seine. The float line preceeded the lead line downstream, lifting the lead line off the bottom. The seine simply passed over the fish, although this was not obvious to the ground crew. The fish did not exhibit frantic behavior, but just returned to their positions over the bottom. When the net was drawn to shore, it contained no fish at all.

Two 7 kg lead weights were attached to the lead line of the seine in an attempt to solve the problem. Fewer fishes escaped initially, during the seventh haul, but it was obvious from the air that the net was visible to them as they swam away from it downstream. The extra lead weights held that portion of the net, to which they were attached, on the bottom. This was evident from the two visible furrows created as the weights dragged along the bottom. However, those portions of the net some distance from the additional weights lifted off the bottom and the fish escaped under the net once again. As before, they were seen to return to their positions over the bottom. This haul yielded only two Arctic grayling which were released.

The modified herring net was used for the eighth haul, with the additional 7 kg weights attached. Although some fishes escaped as the net passed over the scour hole, the remainder were entrapped by the net once it reached the shallows. As the net was drawn together, the fishes were seen to bunch into a tight school. Some raced upstream into the net and were captured by the gills. When the net was drawn to shore, it contained 32 charr and 15 Arctic grayling. The Arctic grayling were released immediately. Thirty-one of the charr were measured for fork length and released. One of the charr, a spawning female, carried a Floy anchor tag (FC 61888). This fish had been tagged in the Firth River by DFO and CPS personnel on 31 August 1987. It was 628 mm at the time of tagging and appeared

not to be in spawning condition. On its recapture it was 652 mm in length.

During underwater photography in this pool prior to seining, the photographer estimated that Arctic grayling comprised 30% of the fishes present. Thirty-two percent of the fishes in the seine haul were Arctic grayling. There is however, some suggestion that Arctic grayling were more likely to be captured in the seine than were charr as the former were the only fish taken in the eighth haul. Given the very limited data, it is only speculation at this point, but catchability bias should be investigated if seining is to be used in future to determine the relative abundance of each species in the headwater pools.

The ninth seine haul took place at Aufeis-C (Fig.5) on 20 September after the US crew had departed for home. The modified herring net was used and 17 charr and 15 Arctic grayling were captured. All the Arctic grayling were released and all of the charr were measured for fork length and released, with the exception of three mortalities.

In summary, seining and mark-recapture does not appear to be a practical method of estimating the size of the Firth River charr population. The charr spawn and overwinter in many pools spread over a wide area and there is evidence that they segregate by size. Therefore, considerable numbers would have to be tagged over this wide area to get a representative estimate of population size. Indeed, some pools which contained charr were too large and/or deep to seine. However, seining would be useful in determining the size and species composition of fish in pools if aerial photography is used for census purposes. Monofilament nets should be used. They are more effective than multi-strand colored nets because they are less visible in the water and are also easier to handle because they produce less drag. The nets should be at least 50 m in length and 2 m in depth. Minimum mesh size should be 38 mm stretched measure (19 mm bar) to reduce the possibility of catching small charr by the gills. Heavy lead line should be used.

FUTURE INITIATIVES

The crew met on the evening of 18 September in the CPS office at Sheep Creek to discuss the results of the survey. All agreed that the objectives of the survey had been met. Members of all participating agencies now had first-hand knowledge of the Firth River system and the advantages and disadvantages of aerial and underwater photography and seining for counting charr were now apparent. A discussion of future plans ensued.

The present and potential impacts on the Firth River charr stock were discussed. It was agreed that available data indicate that the stock is lightly exploited. The CPS creel census showed approximately 100 charr were taken by anglers during the summer of 1989 on float trips down the river. It is assumed that Firth River charr are occasionally harvested by subsistence fisheries along the Beaufort Sea coast although the harvest appears to be light. None of the 495 charr tagged by DFO and CPS in the Firth River in 1987 have been identified as having been caught in these fisheries. To date, anglers have reported taking only two of these charr, both in Alaska. However, all parties are aware that the Inuvialuit, represented on the FJMC, are interested in developing a fishery (subsistence or commercial) on the Firth River stock. The latter represents a significant potential impact. Thus, a management plan that includes all user groups must be developed to ensure wise use of this valuable resource.

It was generally agreed that important spawning and overwintering habitats on both sides of the border are adequately protected by the current land management status. In Canada these areas are entirely within the Northern Yukon National Park and in Alaska they are within the designated wilderness portion of the Arctic National Wildlife Refuge. Habitat disturbances from land use activities are prohibited in both areas. However, Firth River charr are vulnerable to the effects of habitat disturbance as they feed along the nearshore areas of the Beaufort Sea in summer. Impacts associated with oil and gas exploration and development (causeways, oil spills) in this region have the potential to adversely affect the charr and adequate protection must be provided along the coast to ensure the longterm survival of this valuable resource.

The crew agreed that the primary objective of a future study would be to enumerate the charr stock and establish a Safe Harvest Level based on the total count. The management plan would then be formulated using the SHL as an upper limit to exploitation. Results of this study indicate that there are suitable sites at which to install a deflection-board weir in the Firth River to enumerate the charr stock. However, there are important considerations to be made if this technique is to be used.

Previous studies have shown that charr inhabit both the Firth River and Joe Creek (Glova and McCart 1974). Recent population analyses using biochemical techniques suggest that charr from these locations may represent two genetically distinct stocks (Reist 1989). Considering this, enumeration should take place simultaneously on the Firth River upstream of Joe Creek and on Joe Creek itself to get a count of both stocks.

Glova and McCart (1974) found that the arrival of spawners in the upper Firth River preceded that of returning searun migrants by approximately one month and that there was a great increase in searun migrants in this area from the end of August to 21 September 1972. As reported previously (Table 2), returning searun migrant charr were encountered in the upper Firth River on 15 September during this study. Therefore, a weir operation would have to begin no later than the end of July and run for at least seven or eight weeks

in order to count both spawners and returning searun migrants. The expense of operating one or two weirs for this length of time would be considerable.

Ice was observed forming on the banks of the Firth River during the latter part of this study. The arrival of cold weather and icing conditions prior to the end of the count could result in damage to or destruction of the weir with subsequent loss of valuable data. Such a possibility must be considered if a weir is used in future.

The interpretation of the upstream count of returning searun migrants must be done with care. Armstrong (1984) observed that some Dolly Varden charr in Alaska did not overwinter in their natal stream each year. While the existence of genetically distinct stocks requires homing of spawners, returning searun migrants could be a mixture of charr from a number of different stocks. Biochemical studies of charr stocks adjacent to the Firth River stock(s) and an extensive tagging program on spawners could help to determine this. If that proves to be the case, the SHL must be set accordingly.

Following is a list of future objectives and suggested techniques that were identified at the meeting:

Objective	Technique
1. Enumeration of upstream run	Deflection-board weir
2. Quantification of spawning beds and spawners on both sides of border	Aerial/underwater photography, seining
3. Summer distribution of spawners	Radio tags
4. Identification of overwintering sites	Aerial photography
5. Charr/Arctic grayling ratio	Underwater photography, seining
6. Enumeration of "stock" in Joe Creek	Deflection-board weir on Joe Creek above confluence with Firth River or aerial photography, seining
7. Confirmation of discrete "stocks" in Firth River and Joe Creek	Biochemical, morphological studies, tagging
8. Stock identification of charr in streams to the west of the Firth River	Biochemical, morphological studies, tagging
9. Importance of "residual" charr to anadromous population	Graduate studies

In conclusion, it was decided that further field work on the Firth River charr stock(s) should be deferred to allow time to develop a detailed project plan and to allow the respective agencies time to secure the necessary funding. The field survey ended with mutual feelings of satisfaction, friendship and cooperation.

ACKNOWLEDGMENTS

We would like to thank Paul Sutherland and Burton Ayles, DFO Canada and Randy Bailey, USFWS Alaska, Al Ott, ADF&G Alaska, Mel Falk, CPS Canada, and the FJMC, Canada, for their support and encouragement to initiate this project. Thanks also to Vic Gillman and staff, DFO Inuvik, and Bill Dolan, CPS Inuvik, for their significant logistic support. Don Michaud of Sunrise Helicopters, Inuvik, did an excellent job of flying throughout the survey. Bruce Fallis, DFO Canada, reviewed the report and provided helpful suggestions.

REFERENCES

ARMSTRONG, R.H. 1984. Migration of anadromous Dolly Varden charr in southeastern Alaska - a manager's nightmare, p. 559-570. In L. Johnson and B.L. Burns (ed.) Biology of the Arctic charr, Proceedings of the International Symposium on Arctic Charr, Winnipeg, Manitoba, May 1981. University of Manitoba Press, Winnipeg.

GLOVA, G., and P.J. McCART. 1974. Life history of Arctic char (Salvelinus alpinus) in the Firth River, Yukon Territory. In P.McCart (ed.) Life histories of anadromous and freshwater fish in the western Arctic. Arct. Gas Biol. Rep. Ser. 20(3): 37 p.

JOHNSON, L. 1980. The Arctic charr, Salvelinus alpinus, p. 15-98. In E.K. Balon (ed.) Charrs; Salmonid fishes of the genus Salvelinus. Dr. W. Junk, The Hague.

McCART, P.J. 1980. A review of the systematics and ecology of Arctic char, Salvelinus alpinus, in the western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935: vii + 89 p.

McPHAIL, J.D. 1961. A systematic study of the Salvelinus alpinus complex in North America. J. Fish. Res. Board Can. 18: 793-816.

MORROW, J.E. 1980. Analysis of the dolly varden charr, Salvelinus malma, of northwestern North America and northeastern Siberia, p. 323-338. In E.K. Balon (ed.) Charrs: salmonid fishes of the genus Salvelinus. Dr. W. Junk Publishers, The Hague.

REIST, J.D. 1989. Genetic structuring of allopatric populations and sympatric life history types of charr, Salvelinus alpinus/-malma, in the western arctic, Canada. Physiol. Ecol. Japan, Spec. Vol. 1: 405-420.

REIST, J.D., J. JOHNSON, and T. CARMICHAEL. 1990. Morphological variation in charr from northwestern Canada - Salvelinus alpinus and S. malma. Paper presented at the International Society of Arctic Char Fanatics workshop, Dalnie Zelentsy, Murmansk Region, U.S.S.R., September 1990.

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. 191: 382 p.

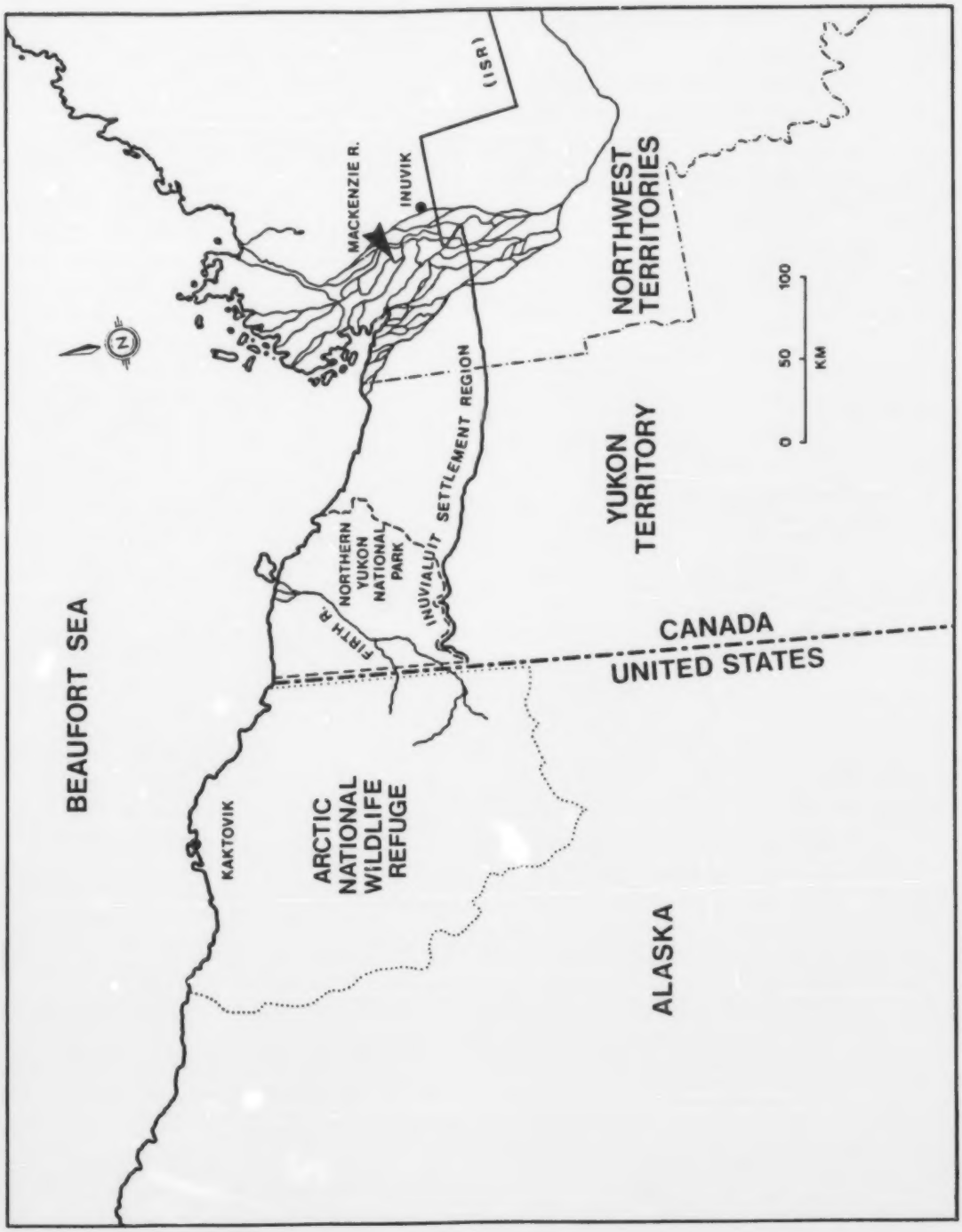

Fig. 1. Map showing the Firth River study area within the Arctic National Wildlife Refuge, Northern Yukon National Park and Inuvialuit Settlement Region.

Fig. 2. The Canadian Parks Service facility at Sheep Creek.

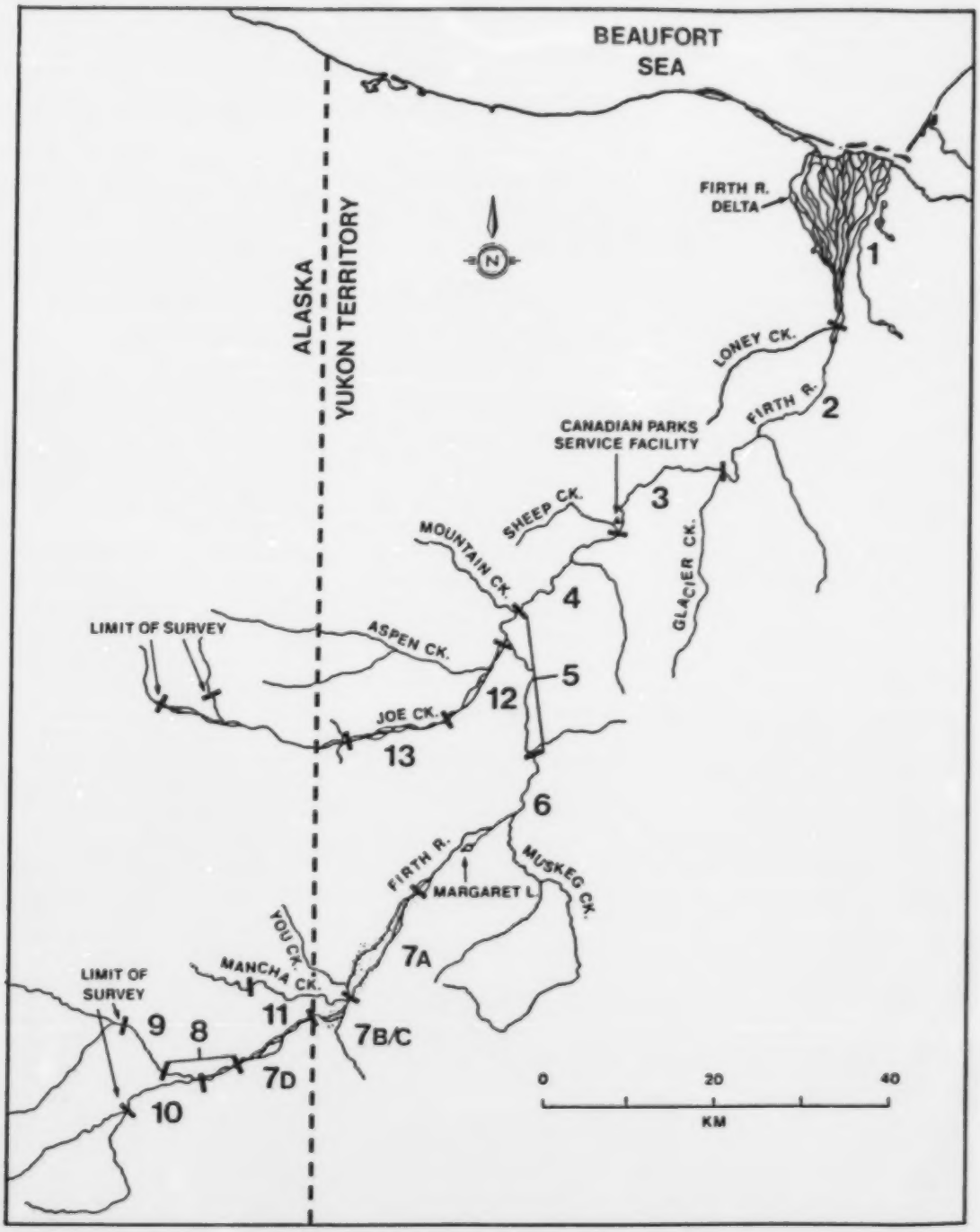

Fig. 3. Map of the Firth River and Joe Creek showing the CPS facility at Sheep Creek and the extent of the aerial reconnaissance flights.

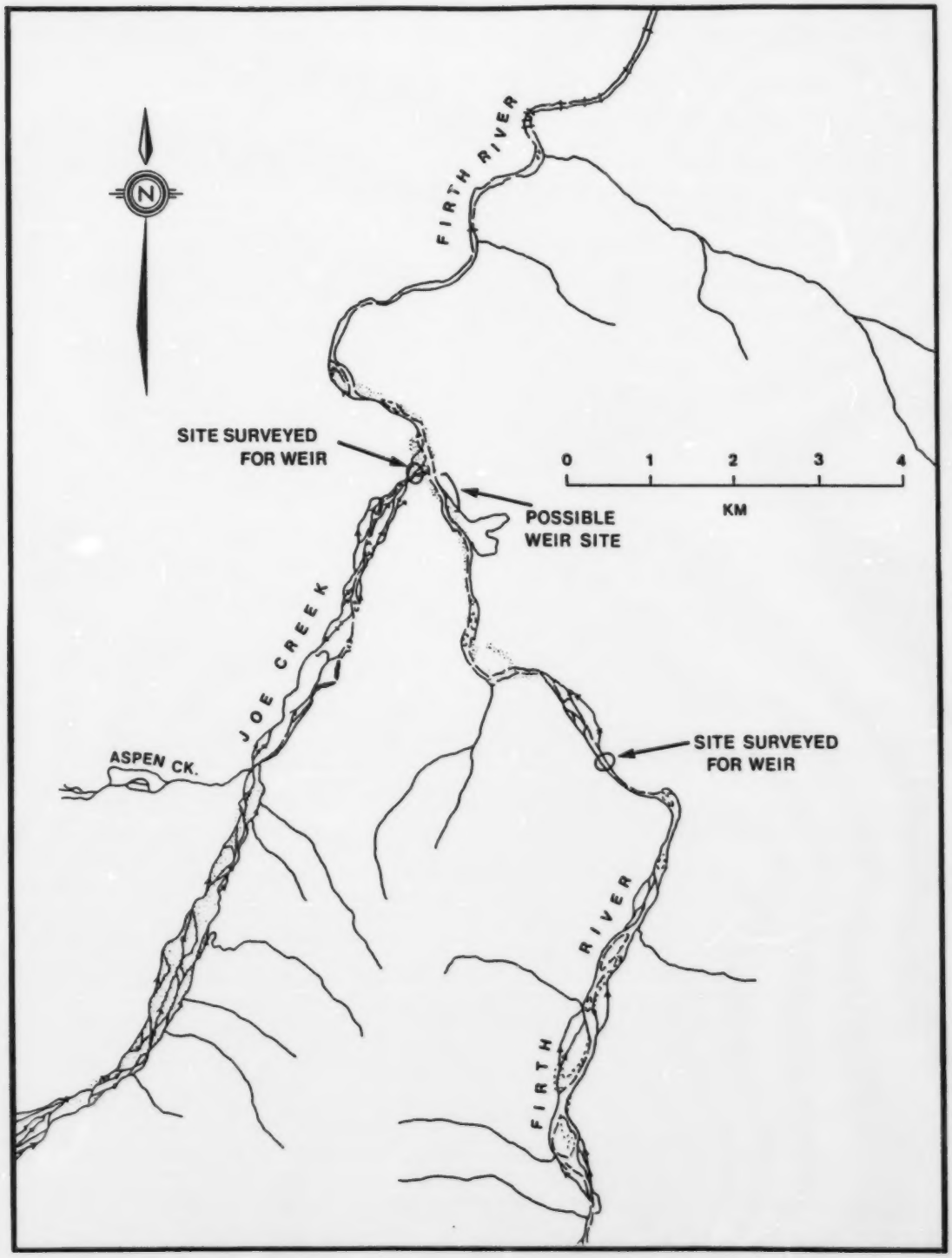

Fig. 4. Map of the confluence of Joe Creek and the Firth River showing sites surveyed for placement of a deflection-board weir operation.

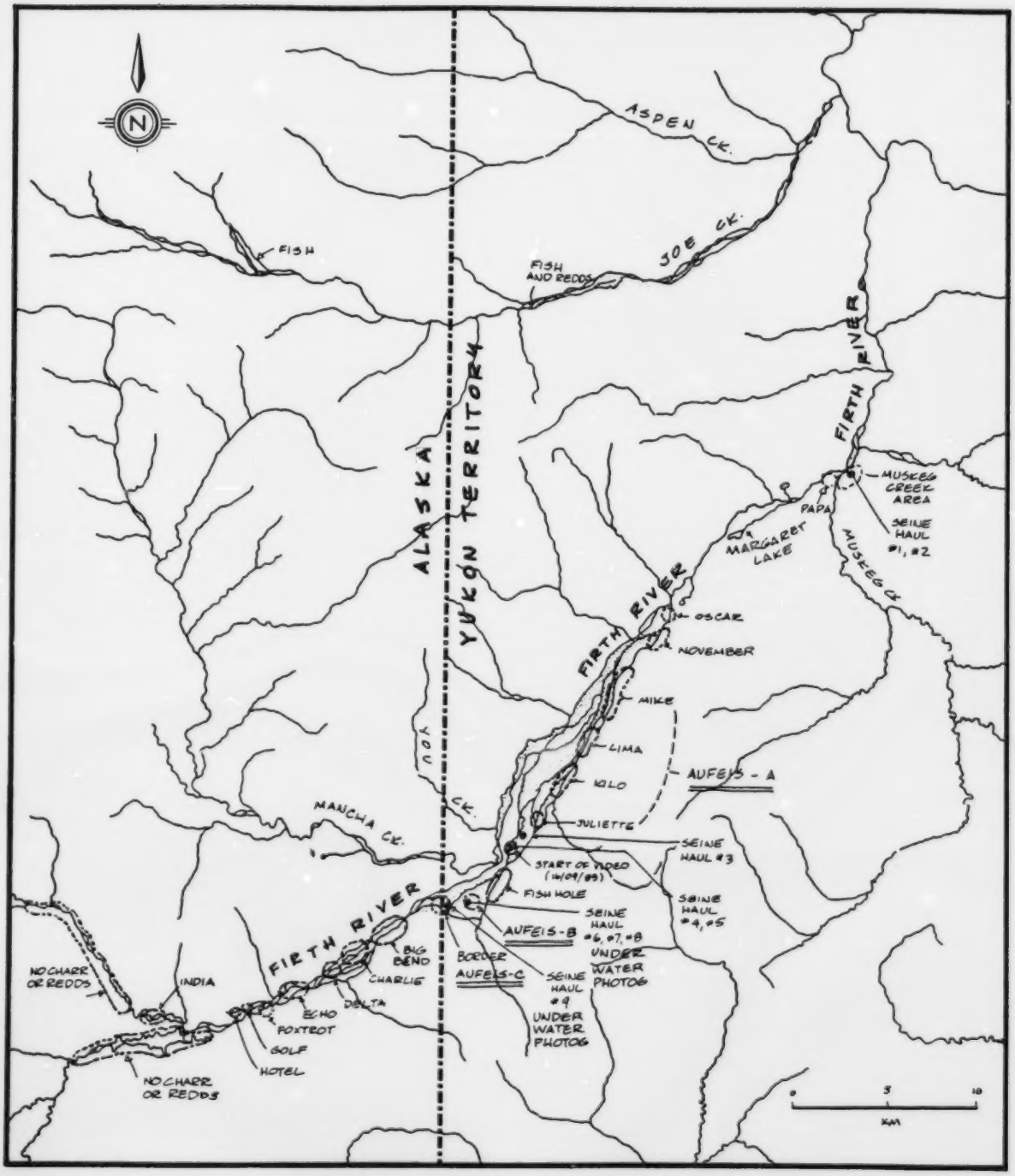

Fig. 5. Map of the upper Firth River and Joe Creek showing seining sites, underwater photography sites and concentrations of fishes and/or redds.

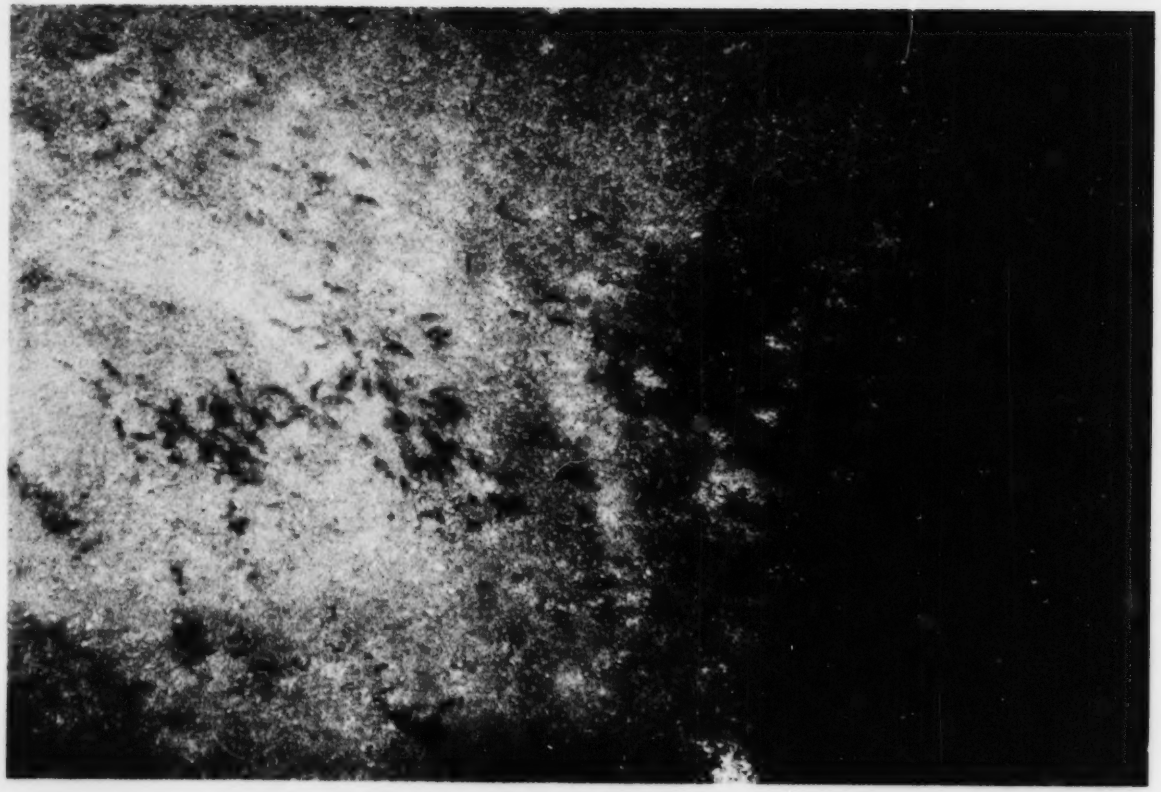

Fig. 6. Aerial photograph of spawning grounds in the upper Firth River. Light-colored patches in middle right are redds.

Fig. 7. Aerial photograph of a seine net haul in the upper Firth River. Fishes are trapped within the seine net but are not visible from the air.

Fig. 8. Underwater photograph of charr and Arctic grayling on spawning grounds in the upper Firth River.

Fig. 9. Photograph of Firth River charr showing male and female current-year spawners and a returning "silver" sea-run migrant. Upper-male; middle-female; lower-"silver".

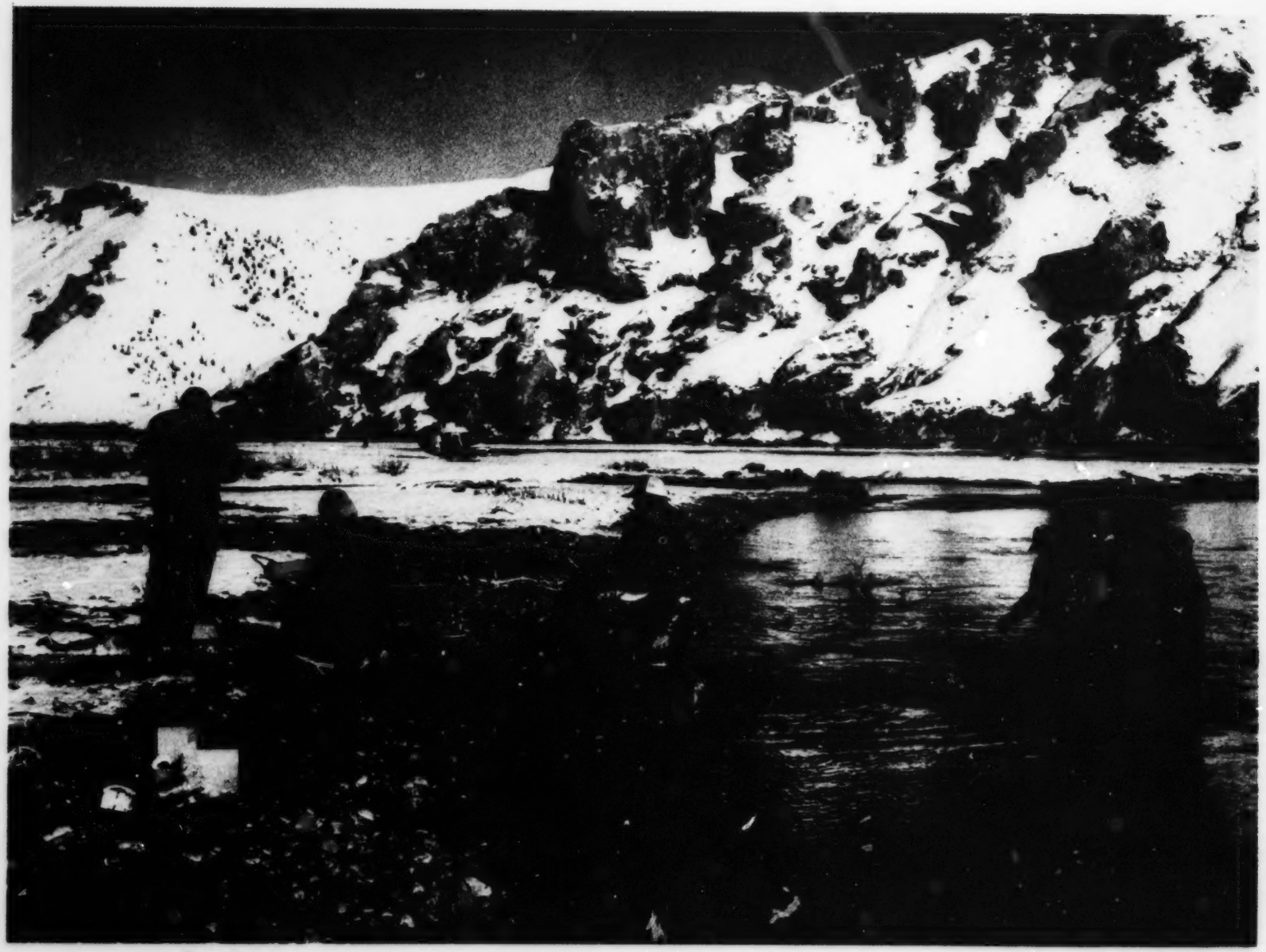

Fig. 10. International field crew sampling charr on the Yukon/ Alaska border after a successful seine haul.

Table 1. Estimated number of fishes and redds in the upper Firth River, 16 September 1989, based on aerial photography (videotape).

Area (Code Name - Fig. 5)	Estimated No. Fishes[1]	Redds
Start of Video	2000-3000+	300+
Fish Hole	300+	200+
Aufeis-B	300+	150+
Border	140+	120+
Big Bend	20+	10+
Charlie	20+	110+
Delta, Echo	200+	50+
FoxTrot, Golf, Hotel	50+	250+
India	70+	110+
Juliette	1000+	800+
Kilo	1000-1500+	100+
Lima, Mike[2]	1500-2000+	50+
November[2]	800-1200+	-
Oscar	50- 100+	-
Papa	300+	-
Confluence-Muskeg Creek	500+	30+
Total	8250-10700+	2280+

[1] Ninety-five percent of fishes (N=606) captured by seine net during this study were charr.

[2] Riffle areas, difficult to count fishes from the air.

Table 2. Record of seine net catches in the upper Firth River, September 1989.

Seine[1] Haul	Location	Date	Charr N	Charr (% Spawners)	Arctic Grayling	Video Record (Y/N)
1	Confl. Muskeg Creek	15	53	(9.4)	0	N
2	Confl. Muskeg Creek	15	26	(0.0)	0	Y
3	Aufeis-A	15	269	(0.0)	0	Y
4	Confl. You Creek	16	54	(0.0)	0	N
5	Confl. You Creek	16	123	(0.0)	0	N
6	Aufeis-B	17	0	-	0	Y
7	Aufeis-B	17	0	-	2	Y
8	Aufeis-B	17	32	(40.6)	15	Y
9	Aufeis-C	20	17	(35.3)	15	N
Total			574	(4.2)	32	

[1] A modified monofilament herring gillnet was used for all seine hauls except nos. 6 and 7, where a black-coloured, multi-strand beach seine was used.

Table 3. Biological data from charr captured by seine net in the upper Firth River, September 1989.

Seine Haul	Fork Length (mm)											
	Male Spawners				Female Spawners				Silvers			
	N	Mean	(SD)	Range	N	Mean	(SD)	Range	N	Mean	(SD)	Range
1	3	593.3	(52.8)	536-640	2	443.5	(26.1)	425-462	48	441.3	(58.2)	269-588
4			-				-		19	468.7	(126.8)	298-680
8	7	570.7	(113.1)	411-750	6	556.7	(88.9)	451-652	18	404.9	(94.0)	302-575
9	1	508.0	(-)	-	5	555.0	(38.5)	524-615	11	490.2	(52.6)	402-572
Total	11	571.1	(93.7)	411-750	13	538.6	(75.0)	425-652	96	445.5	(85.2)	269-680